**Remarks**

Reconsideration of pending Claims 1-73 and 101-129 is respectfully requested.

The claims under consideration are as amended in the Response filed on April 7, 2004.

**Rejection of Claims under 35 U.S.C. § 112(2)**

The Examiner rejected Claims 1-3, 6-10, 35, 101, 106, and 112 under Section 112(2) for the use of indefinite claim language, referring to the Office Action mailed February 4, 2004. This rejection is respectfully traversed.

The Examiner states that "Applicant provides no response to the rejection" (Office Action at page 2).

The Examiner is directed to the Advisory Action (mailed April 28, 2004) at paragraph 3 (copy enclosed; emphasis added):

> Applicant's reply **has overcome** the following rejection(s): **the rejection under 35 USC 112, paragraph 2**.

The Examiner is further directed to page 24 of the Response After Final, filed by Applicant on April 7, 2004 (copy enclosed). As noted, Claims 1, 4-5, 35, 101, 106, 109, and 110, were previously amended in response to the Examiner's rejection.

It is submitted that Applicant has previously and fully responded to the Examiner rejection of the claims under Section 112(2). Accordingly, withdrawal of this rejection is respectfully requested.

**Rejections under 35 U.S.C. § 103(a) (Wang with Hu)**

The Examiner continues to maintain the rejection of Claims 1, 2, 3-9, 11-14, 16-19, 21-24, 26-28, 30, 31, 34, 35, 37, 38, 40-45, 49, 68, 71, 101-105, 112, 114, 116, 120 and 121 under Section 103(a) as being obvious over Wang (US 2002/0155219) in view of Hu (USP 6,436,820), referring to the Office Action mailed February 4, 2004. This rejection is respectfully traversed.

Wang teaches forming a TiN film using a hydrogen-containing plasma treatment at about **500-600°C.** to produce a TiN film having a chlorine content of **1.5%** and a resistivity of about **180** μohm-cm. Further, in a comparative example, Wang discloses a thermal anneal of a TiN film in $NH_3$ at a temperature of about **580°C**. resulted in a chlorine concentration of about 3%, a resistivity of about 320 μohm-cm, and an increase in sheet resistance of about 40% (at [0045] and [0046]).

Hu discloses forming a TiN film using multiple depositions and annealing steps to remove chlorine. Hu teaches annealing a TiN film in $NH_3$ at a temperature of **680°C.**, resulting in a chlorine concentration of about **1.5** atomic % and a resistivity of about **175** μohm-cm.

The Examiner maintains that there is motivation to (1) substitute Hu's **680°C.** $NH_3$ thermal anneal in Wang's process for the purpose of reducing the chlorine content and resistivity of the TiN film, and (2) then ***increase*** Hu's 680°C. **by 20°C.** to Applicant's temperature of about 700°C. or greater (or greater than about 700°C.; or about 700-800°C.).

Although Hu discloses a lowered chlorine concentration and resistivity resulting from a **680°C.** $NH_3$ thermal anneal, there is no motivation to utilize the higher temperature in Wang's process despite the purported advantages.

First of all, although Hu discloses the use of a 680°C. $NH_3$ thermal anneal to achieve a chlorine concentration of about 1.5 atomic % and a resistivity of about 175 μohm-cm — these are at about the ***same levels*** as Wang achieves using a **$H_2$ plasma at 500-600°C.**, i.e., a chlorine concentration of about 1.5% and a resistivity of 180 μohm-cm.

Thus, there is no good basis for one of skill in the art to modify Wang's process by increasing the temperature to Hu's 680°C. or higher since Wang's processing at 500-600°C. in a $H_2$ plasma achieved about the ***same results*** as Hu— but ***at a lower temperature***.

Second, the increase in process temperature in Wang's method proposed by the Examiner is an about ***100°C. increase*** — from Wang's **500-600°C.** temperature to Hu's **680°C.** temperature to Applicant's **700°C.** temperature or greater.

Additionally, Wang teaches that a low processing temperature of ***less than 600°C.*** should be used to form a TiN film in order to achieve the stated goal of (a) improving step coverage, and

(b) avoiding damage to previously formed layers and structures. At [0009] and [0051], Wang states that even though the chlorine content can be reduced by increased deposition temperature, a lower deposition temperature provides the improved step coverage — a stated objective of Wang's disclosure.[1] In addition, Wang states at [0009] and [0051] that his TiN deposition and $H_2$ plasma treatment performed at a low processing temperature *avoids undesirable effects* on other material layers and structures— another stated objective of Wang's disclosure. (Emphasis added)

> [0009] *Although the Cl content in the deposited TiN film can be reduced by increasing the deposition temperature, improved step coverage is favored by lowering the deposition temperature*. Furthermore, a relatively low deposition temperature is advantageous for process integration purposes. For example, TiN can be used as a barrier layer for an upper electrode in a capacitor structure with tantalum pentoxide ($Ta_2O_5$) as the dielectric. However, thermal CVD of TiN—e.g., using a reaction between $TiCl_4$ and $NH_3$, is **often performed at a temperature of about 650°C. Such a high temperature may cause undesirable atomic inter-diffusion within the capacitor structure.**
>
> [0051] ...A TiN barrier layer 406 is then formed upon the $Ta_2O_5$ dielectric layer 404, **preferably at a low processing temperature so as to avoid undesirable inter-diffusion across the various material layers**. This can be achieved, for example, by the process of the present invention....

One skilled in the art would *not* be motivated to modify Wang's process to incorporate a process step utilizing a temperature greater than the 500-600°C. temperature taught by Wang — particularly where Wang's 500-600°C. processing in a $H_2$ plasma achieves the *same results* as Hu' 680°C. processing — and *with the added benefit* of good process integration with previously formed layers and structures, which Wang teaches is not achieved at temperatures of 650°C. or greater (see above at [0009]).

Accordingly, withdrawal of the rejections of the claims is respectfully requested.

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[1] See Abstract (emphasis added): "This results in a thick titanium nitride film with low resistivity and *good step coverage*."

See Background at [0010] (emphasis added): "Therefore, a need exists in the art for a method of depositing TiN at a reduced temperature, to yield thick", crack-free TiN films having improved properties including *good step coverage* and low resistivity.

See Detailed Description at [0021] (emphasis added): "The present invention provides a method of forming a thick titanium nitride ...film with low resistivity and *good step coverage*.

**Rejections under 35 U.S.C. § 103(a) (Wang with Hu and Leem or JP '220)**

The Examiner maintains the rejection of Claim 115 based on the combination of Wang and Hu with Leem (USP 6,436,820) or Japan '220 (Japan 5-267220), referring to the Office Action mailed February 4, 2004. The Examiner maintains the rejection of the claims on the basis that one of skill in the art would be motivated to incorporate boron into the TiN material of Wang based on the disclosure of either Leem or Japan '220.

The Examiner maintains the rejection of Claims 10, 15, 20, 25, 29, 32, 39, 50-59, 61-63, 66, 67, 69, 70, 72, 73, 106-111, 113, 117-119, 122, and 123 based on the combination of Wang with Hu, further in view of Leem or Japan '220, referring to the Office Action mailed February 4, 2004. In the Office Action of February 4, 2004, the Examiner stated that Leem or Japan '220 provide motivation to form one or more of the titanium nitride layers of Wang using titanium boronitride.

These rejections are respectfully traversed.

As stated above, the Examiner has failed to establish a *prima facie* case of obviousness based on the combination of Wang and Hu due to a clear lack of motivation to increase the process temperature of Wang from 500-600°C. to a temperature of 680°C. as described by Hu.

Neither Leem nor Japan '220 make up for those deficiencies, and the combination of those two references with either Wang and/or Hu does not would not provide Applicant's method as claimed.

Accordingly, withdrawal of these rejections is respectfully requested.

**Rejections under 35 U.S.C. § 103(a) (Wang with Hu, and Doan)**

The Examiner maintains the rejection of Claims 36, 46, 47, 48, 64 and 65 based on the combination of Wang and Hu with Doan (US 2001/0006240), referring to the Office Action mailed February 4, 2004. This rejection is respectfully traversed.

In the Office Action of February 4, 2004, the Examiner stated that, although not disclosed by Wang, Doan would provide motivation to form a titanium silicide layer by PECVD or sputtering.

First of all, Applicant repeats the request to ***withdraw*** this rejection of **Claims 46-48** — as requested in both the Response filed November 10, 2003 (at page 30) and the Response filed April 7, 2004 (at page 34). As shown below, these claims do *not* recite the formation of a $TiSi_2$ layer by PECVD or sputtering:

> **Claim 46**: A method of forming a contact, comprising:
> depositing a first source gas comprising $TiCl_4$, $H_2$, and $SiH_4$ precursors onto a substrate to form a titanium silicide layer in an opening;
> depositing a second source gas comprising $TiCl_4$ and $NH_3$ precursors onto the titanium silicide layer to form a titanium nitride layer;
> removing excess of the titanium nitride layer by chemical mechanical polishing while maintaining the titanium nitride layer within the opening to form the contact; the contact having a concentration of chlorine; and
> exposing the contact to a nitrogen-containing gas by thermal anneal at a temperature of about 700°C. or greater to reduce the concentration of chlorine of the contact.
>
> **Claim 47**: The method of Claim 46, wherein the nitrogen containing gas comprises ammonia.
>
> **Claim 48**: The method of Claim 46, wherein the thermal anneal is conducted at a temperature of at least about 700°C. to about 800°C.

As to Claims 36 and 64-65, the mere formation of a $TiSi_2$ layer in the titanium nitride film construction of Wang does not make does not make up for the above-stated deficiencies in the rejection of the claims based on the Examiner's combination of Wang with Hu.

**Rejections under 35 U.S.C. § 103(a) (Wang with Hu, with AAPA)**

The Examiner rejected Claims 60 and **124**, 125, 126, and **127** based on the combination of Wang and Hu in view of "applicant's admitted prior art (AAPA)," referring to the Office Action mailed February 4, 2004. This rejection is respectfully traversed.

The Examiner maintains that it would be obvious to combine Wang's disclosure of forming a contact to a source/drain with the purported AAPA of forming aluminum interconnects over contacts to form a source/drain contact and/or an interconnect.

First of all, Applicant repeats the request to ***withdraw*** this rejection of **Claims 124 and 127** — as requested in the Response filed April 7, 2004 (at page 35). As shown below, these claims do *not* recite the formation of a source/drain contact or interconnect:

**Claim 124**. A method of forming a semiconductor device, comprising the steps of:
forming a layer of titanium nitride over a substrate;
heating the titanium nitride layer in a reactive gas at a temperature of about 700°C. or greater to remove chlorine from the layer; and
depositing a conductive layer over the titanium nitride layer.

**Claim 127**. A method of forming a semiconductor device, comprising the steps of:
depositing a gaseous mixture comprising titanium tetrachloride and ammonia on a substrate to form a layer of titanium nitride;
heating the titanium nitride layer in a reactive gas at a temperature of about 700°C. or greater to remove chlorine from the layer; and
depositing a conductive layer over the titanium nitride layer.

As to Claims 60 and 125-126, the mere formation of the contact to an S/D region in the substrate, or the formation of an interconnect over the titanium nitride film of Wang does not make does not make up for the above-stated deficiencies in the rejection of the claims based on the Examiner's combination of Wang with Hu.

Accordingly, these rejections are respectfully traversed.

**Extension of Term.** The proceedings herein are for a patent application and the provisions of 37 CFR § 1.136 apply. Applicant believes that no extension of term is required. However, this conditional petition is being made to provide for the possibility that Applicant has inadvertently overlooked the need for a petition for extension of time. If any extension and/or fee are required, please charge Account No. 23-2053.

Based on the above remarks, the Examiner is respectfully requested to reconsider and withdraw the rejections of the claims. It is submitted that the present claims are in condition for allowance, and notification to that effect is respectfully requested.

Respectfully submitted,

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Dated: November 17, 2004

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